Preprint
UCRL-JC-146959

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This article was submitted to
Institute of Electrical and Electronics Engineers Antennas and Propagation Society Symposium, San Antonio, TX, June 16-21, 2002

January 28, 2002

U.S. Department of Energy

Lawrence
Livermore
National
Laboratory

This work was performed under the auspices of the United States Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

On Attaching a Wire to a Triangulated Surface

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Introduction

There have been many papers that have focused on the attachment of wires to surfaces. The focus of this paper will be on wires connected to arbitrarily shaped surfaces, a body that may be modeled with triangles as described in [1]. The basis function for the wire-to-surface junction is constructed by building the $1/r$ variation of the surface current near the junction into the surface current. In the following we summarize junction bases as currently used. In the presentation we consider their numerical implementation, examine alternative formulations, and review validation studies that prove the approach is robust with respect to wire orientation and surface geometry at the junction.

Basis Function Formulation

The parameters for the junction basis function are illustrated in Figure 1. The basis function for the nth junction on a structure, as proposed in [2], is given by

$$\boldsymbol{\Lambda}_n^J(\mathbf{r}) = \begin{cases} K_{nl}\left[1 - \dfrac{\left(h_{nl}^{J+}\right)^2}{\left(\boldsymbol{\rho}^+ \cdot \hat{\mathbf{h}}_{nl}^{J+}\right)^2}\right]\boldsymbol{\Lambda}_{nl}^B(\mathbf{r}), & \mathbf{r} \text{ on } S_{nl}^{J+} \\ \boldsymbol{\Lambda}_n^W(\mathbf{r}), & \mathbf{r} \text{ on } S_n^{J-} \\ 0, & \text{otherwise,} \end{cases} \tag{1}$$

where S_{nl}^{J+} is the lth triangle connected to the nth junction, and S_n^{J-} is the wire connected to the nth junction. The basis functions $\boldsymbol{\Lambda}_{nl}^B(\mathbf{r})$ and $\boldsymbol{\Lambda}_n^W(\mathbf{r})$ are the body (surface) basis function [1], associated with the edge opposite the junction vertex, and the wire basis function [2], respectively. The height vector $\mathbf{h}_{nl}^{J+}$ of the triangle is directed from the junction vertex to the edge opposite the junction vertex. The quantity $\boldsymbol{\rho}^{+}$ is the vector from **r** on S_{nl}^{J+} to the junction vertex. The coefficient K_{nl} is chosen as

$$K_{nl} = \frac{\alpha_{nl}}{\ell_{nl} \sum_{l=1}^{NJn} \alpha_{nl}} = \frac{\alpha_{nl}}{\ell_{nl} \alpha_n^t} \tag{2}$$

so that the total flux from the attached triangles into the wire is unity. Here, α_{nl} is the angle between the two edges of S_{nl}^{J+} common to the junction vertex. The sum of these angles about the junction vertex is α_n^t. The number of triangles attached to the junction is NJn, and the length of the edge opposite the junction vertex is ℓ_{nl}. The surface divergence of (1) is given by

$$\nabla_S \cdot \mathbf{\Lambda}_n^J(\mathbf{r}) = \begin{cases} \dfrac{2K_{nl}}{h_{nl}^{J+}}, & \mathbf{r} \text{ on } S_{nl}^{J+} \\ -\dfrac{1}{h_n^{J-}}, & \mathbf{r} \text{ on } S_{nl}^{J-} \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

The surface current on the bodies is represented as

$$\mathbf{J}(\mathbf{r}) \approx \sum_{n=1}^{NB} I_n^B \mathbf{\Lambda}_n^B(\mathbf{r}) + \sum_{n=1}^{NJ} I_n^J \mathbf{\Lambda}_n^J(\mathbf{r}), \quad \mathbf{r} \text{ on } S_B, \tag{4}$$

and the axial current on the wires is given by

$$\mathbf{I}(\mathbf{r}) \approx \sum_{n=1}^{NW} I_n^W \mathbf{\Lambda}_n^W(\mathbf{r}) + \sum_{n=1}^{NJ} I_n^J \mathbf{\Lambda}_n^J(\mathbf{r}), \quad \mathbf{r} \text{ on } S_W, \tag{5}$$

where the total number of unknowns (N) is equal to the number of surface current unknowns (NB) plus the number of wire current unknowns (NW) plus the number of junction current unknowns (NJ).

Results

The geometry for a wire inside a conducting box with two apertures is shown in Figure 2 [3]. The wire is excited by a 1 V source and is loaded at both ends with a 50 Ω load. The normalized current at the wire end opposite the source is shown in Figure 3. The experimental results are from [3], and the numerical results are calculated using EIGER [4]. The data labeled as one region are obtained using the EFIE. The two-region results are calculated by using electric and magnetic currents in the aperture in addition to the EFIE. The interior and exterior regions are isolated by only allowing coupling through the aperture. Finally, the Green's function results are from using a periodic Green's function to mimic a cavity Green's function. All the numerical results show good agreement with the experimental data.

Conclusion

The junction basis function proposed in [2] is designed to model the surface current variation near a wire-to-surface junction, where the surface is composed of arbitrary collections of triangles. The results presented demonstrate that the junction basis function can provide accurate currents.

Acknowledgments

This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48 and by Sandia National Laboratories, a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, under contract No. DE-AC04-94AL85000.

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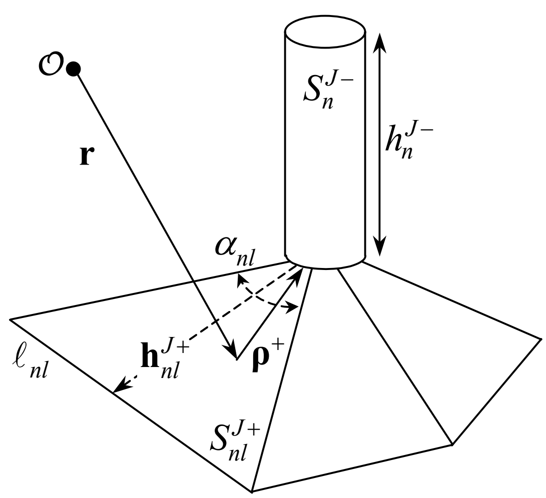

Figure 1. The wire-to-surface junction geometry and its associated parameters.

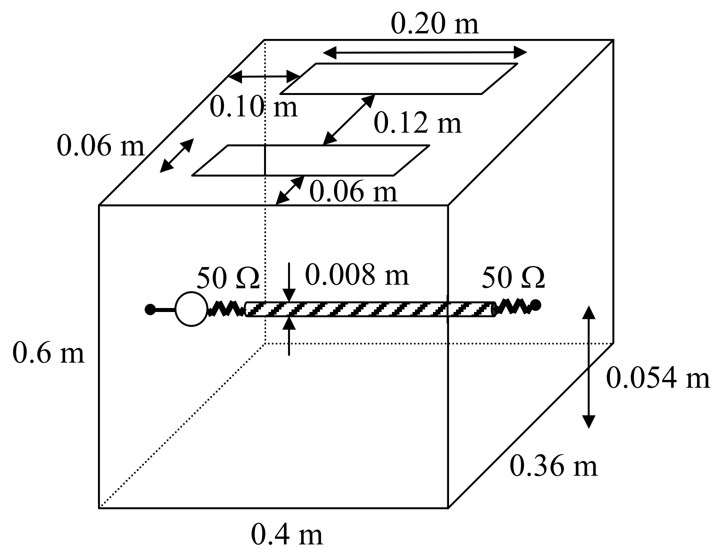

Figure 2. A conducting box with two apertures on the top and a wire with 50 Ω loads terminating on the box walls.

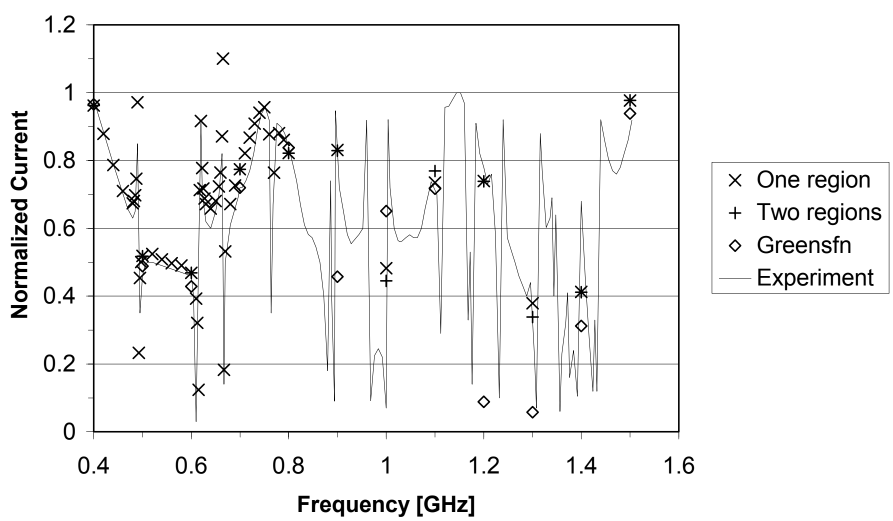

Figure 3. The current (normalized to 10 mA) on the wire end without the excitation.